Remarks

Thorough examination by the Examiner is noted and appreciated.

The claims have been amended to overcome Examiner objections and rejections and to further clarify Applicants invention and define over the prior art. No new matter has been added.

Support for the amendments is found in the previously presented claims, the Figures and the Specification at:

[0007] When processing semiconductor wafers using a plasma, it is normally desirable to achieve uniform processing over the entire surface of the wafer. Unfortunately, however, the density distribution of the plasma is often not uniform over the wafer, but instead varies as a result of a number of factors, such as non uniform heating of the wafer, variations in the physical geometry of the chamber **which in turn affects distribution of the plasma within the chamber, and variations in the electrical field producing the plasma due to non-uniformity of the RF bias potential over the face of the wafer. As a result of such variations, deposition and/or etch rates vary over the wafer in a manner that may not always be predicted,** and where predictable, require that additional measures be taken to compensate for the variations.

[0008] Accordingly, there is a need in the art for a method and apparatus which produces **a plasma over the face of the wafer that has uniform density to allow repeatable and consistent processing of wafers.** The present invention is directed toward satisfying this need.

[0024] Referring first to FIG. 1, a conventional prior art, **monopole ESC is depicted comprising a plate 14 for holding a semiconductor wafer 12** thereon within a processing chamber 10. The ESC plate 14 is connected to a DC power supply 22 using a DC/RF coupler 24. The wafer 12 is separated from the plate 14 by a thin layer of a dielectric (not shown). The DC power supply 22 charges the plate 14 which causes charge separation on the bottom surface of the wafer 12, resulting in the latter being attracted to and clamped to the plate 14. An RF electric field is created within the chamber 10 using a RF power source 18 which delivers RF power through a matching network 20 and the DC/RF coupler 24 to plate 14 which acts as a first electrode. The alternating voltage applied by the RF power source to the first electrode plate 14 is known as the RF bias voltage. A second electrode 16 cooperates with the electrode plate 14 to produce an electric field over the upper surface of the wafer 12 within the chamber 10. As previously described, this RF electric field produces a plasma within the chamber 10 adjacent to and covering the upper face of the wafer 12. Due to a number of factors, including the physical configuration of the chamber 10, corrosion resistance, cooling characteristics and chucking force, the plasma created across the face of the wafer 14 may not have an even distribution, but rather, as shown by the plot 26 in FIG. 2, is lower in magnitude near the edges of the wafer 12, and is greater toward the center of the wafer. The non-uniformity of the plasma density over the face of the wafer 12 is related to the fact that the change of the RF bias voltage applied to the electrode plate 14 is not constant over the face of the plate 14. This can be seen from FIG. 3, wherein the curve plot 28 represents the change of the RF bias voltage applied to the prior art electrode 14 as a function of time, i.e. dV/dT, varies over the distance "d" across the face of the plate. As a result of these non-uniformities, **the processing results e.g. deposition or etch rate, over the face of the wafer are likewise nonuniform**. In some cases, it may be possible to partially compensate for these process variations, but such compensation, even where possible, will require trial and error, resulting in scrap and reduction of throughput. In other cases, it may be impossible to compensate for the process variations.

Claim Objections

The claims have been amended to overcome Examiners objection.

Claim Rejections under 35 USC 112

The claims have been amended to overcome Examiners rejections.

Claim Rejections under 35 USC 103

1. Claims 1-4, 7, 9, 21, 22, 24-28, and 30-32 stand rejected under 35 USC 103(a) as being unpatentable over Dible et al. (US 6,239,403) in view of Liu et al. (US 2003/0038112).

Dible et al. discloses a power segmented electrode for use as **an upper electrode and/or substrate support** (see Abstract) which is individually supplied with RF power to provide for uniform processing of a substrate (see Abstract). In one embodiment (upper electrode embodiment), Dible et al. discloses a segmented electrode and an **active mechanism** to control power delivered to different zones of the segmented electrode including a **capacitive network** for distributing power to a plurality of

electrodes which may be segmented into concentric annular rings (see Figure 5, col 3, lines 30-49;; col 4, lines 54-61; col 6, lines 13-24—see also particularly col 2, lines 33-48 and especially lines 45-46). Dible et al. **does not disclose** that the embodiment with a capacitive network (Figure 5) **is incorporated into an electrostatic chuck**, bur rather discloses that in this embodiment, the current sensing mechanisms (sensing current through variable capacitors) is provided for automatically adjusting the variable capacitors **<u>by a feedback loop</u> between the current sensors and the variable capacitors** to control the **percentage of power** sent to the electrodes (col 6, lines 13-24) to compensate for deviations from uniformity of **processing the substrate in an annular zone of the substrate <u>facing</u> a respective one of the annular electrodes** (col 2, lines 41-47). That is, this embodiment **is disclosed to be an upper electrode not a substrate support** or **not comprising an electrostatic chuck**.

In different embodiments, Dible et al. (Figure 1a and Figure 2) disclose a passive network system that is incorporated into a **bipolar electrostatic chuck** (Figure 1a) (col 5, lines 16-24) and may use a DC bias to provide for electrostatic clamping (Figure 2; col 5, lines 49-51) and which includes a **passive RF power splitter** (26; Figure 2) for delivering power to different segments of the segmented electrode (col 5, lines 37-57).

Dible et al. **further discloses that** two variable capacitors may be used to supply RF power to each pole **(bipolar chuck)** of an ESC wafer clamping system (Figure 6; col 6, line 23-29) where the first electrode (8) is separate from the **chuck which acts as a second electrode** (6) in a **bipolar chuck** (see Figure 1a)).

Thus Dible fails to disclose several elements of Applicants invention, including those elements in **bold type**:

"A method of c**ontrolling the spatial distribution of RF power** used to generate a plasma for processing a semiconductor device process wafer to achieve a **uniform deposition and/or etch rate** over an entire face of said process wafer, comprising the steps of:

(a) producing RF power from **first and second RF power generators comprising a dual frequency system, said first RF power delivered to a first electrode positioned above and spaced apart from a second electrode;**

(b) **delivering said second RF power** to each of a plurality of separate electrode zones according to a matching network, said separate electrode zones comprising said second electrode, said

second RF power individually deliverable in parallel from said matching network to separate electrode zones at a selected RF power level **through a plurality of variable capacitors**, each of said variable capacitors associated with one of said electrode zones, said separate electrode zones comprising an electrostatic chuck; and

(c) **separately controlling the second RF power delivered to each of the electrode zones so as to produce a desired spatial distribution of said second RF power** across said process wafer face in **response to determining a uniform deposition and/or etch rate over of said plasma over said process wafer face**, said desired spatial distribution of said RF power selected to achieve a uniform deposition and/or etch rate over said entire surface of said process wafer."

Examiner argues that Dible teaches impedance matching and refers to discussion in the prior art (col 1, lines 41-49) that discloses a completely different system than that of Dible, where RF power is supplied to a **conductive coil outside the plasma reactor chamber** according to a **matching circuit** having a primary coil and a secondary loop. Examiner also refers to (col 5, lines 16-36) where Dible teaches with respect to the embodiment shown

Figures 1(a) and 1(b) that the **inherent series capacitance** supplied by spacings (gaps) between the first and second electrodes "can be chosen to match the voltage requirements at each zone based on known RF phase and matching requirements".

In response, Examiner merely responds "Without being specific, Applicant has argued repeatedly against limitation clearly present in the prior art as disclosed".

Applicants therefore resummarize the above specific statements related to the teachings of Dible:

1. Dible et al. nowhere teaches that the embodiment including an active network including variable capacitors with a current sensing feedback loop to the variable capacitors (see Figure 5) is incorporated into an electrostatic chuck but rather teaches that the **annular electrodes compensate for deviations** from uniformity of **processing the substrate in an annular zone of the substrate <u>facing</u> a respective one of the annular electrodes** (col 2, lines 41-47). That is, this embodiment **is disclosed to be an upper electrode i.e., <u>not comprising an electrostatic chuck</u> and that deviations from uniformity are adjusted in an annular zone of the substrate in this embodiment, i.e., not across an entire face.**

With respect to claims 36-38:

2. In the embodiments that Dible discloses can be incorporated into an electrostatic chuck (Figures 1A, 2, and 6) Dible discloses **a bipolar electrostatic chuck and specifically an embodiment where an RF power is delivered to the electrostatic chuck (Figure 6) i.e.,** Dible et al. **discloses that** two **variable capacitors may be used to supply RF power to each pole of an ESC wafer clamping system** (Figure 6; col 6, line 23-29) **where the first electrode (8) is separate from the chuck which acts as a second electrode (6).**

On the other hand, Liu et al. disclose a method for optically monitoring the **integrated power spectra** by optical sensors (176; Figure 1; paragraph 0048) **located in an upper electrode** (60) over selected areas of a process wafer(50), where the **upper electrode is segmented** (Figure 2A) and where **each segment** of the electrode **is supplied by a separate RF power supply** (82; Figure 2b, 2C) **each RF power supply controllable** to **alter the RF power of an individual electrode segment** (see Abstract). Liu teach that **each RF power supply is controllable to adjust the RF power level** of a plasma **based on differences in an integrated power spectra from a predetermined value** (paragraph

0018). Liu et al. disclose monitoring the power spectrum over portions of the wafer face (see Figure 9; paragraph 0071) and teach that the magnitude of the total power spectrum should be the same over monitored portions of the wafer (Pa-Pc; Figure 9).

The RF power from each of the separate RF power supplies is adjusted to each of a corresponding electrode segment **to adjust the magnitude of the total power spectrum** to a predetermined value. Liu et al. teach that in achieving overall plasma processing uniformity in endpoint detection in an etching process may include predetermined application of **different RF power levels to the overhead electrode** as well as in-situ adjustment of **individual power supplies to each of the electrode segments** based on comparison **to a predetermined level of a magnitude of the power spectrum of the plasma** (paragraphs 0081 and 0082).

Examiner argues that it would have been obvious to modify Dible to incorporate plasma sensors in the apparatus of Dible et al.

However, even assuming *arguendo* that Dible could be successfully modified to incorporate the sensors of Liu to **control separate RF power supplies supplying RF power to separate electrode segments Dible**, such modification would **change the**

principle of operation of Dible, **make it unsuitable for its intended purpose**, and still not produce Applicants invention.

Examiner merely states in response to the above argument that he does not understand Applicants argument.

Applicants therefore reiterate that there must be some suggestion or teaching in the prior art for modifying the single RF supplied segmented electrode/electrostatic chuck of Dible and such modification must be able to be done **without changing the principle of operation of the device of Dible or making it unsuitable for its intended purpose**.

The suggested modification would apparently be to incorporate the **optical sensor system** of Liu into Dible which could only be done by providing **separate RF power supplies supplying each of the segments of the segmented <u>upper</u> electrode** of Dible (**which would change the principle of operation** of the **single RF supply of Dible** provided through a capacitor network to the individual segments of the annular segmented electrode of Dible) as well as **change the principle of operation** of adjusting the capacitor network of Dible (**feedback loop of RF current sensors and variable capacitors**) by supplying the optical sensors of Liu.

Thus, Applicants statement is simply that any such modification of Dible by the teachings of Liu to provide optical sensors in Liu is **impermissible *as a matter of law*** *since any modification of Dible by Liu in an attempt to produce Applicants invention* ***would change the principle of operation of Dible (single RF supply where power is adjusted by a RF current sensor/variable capacitor feedback loop) and make it unsuitable for its intended purpose of (adjusting the power supplied by a single RF power supply by using an RF current sensor/variable capacitor feedback loop).***

"If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious." *In re Ratti, 270 F.2d 810, 123, USPQ 349 (CCPA 1959).*

"If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification." *In re Gordon, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).*

Moreover, modification of Dible by providing optical sensors still **would not produce** the elements of Applicants invention.

"**First**, there must be some **suggestion or motivation**, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. **Second**, there must be a **reasonable expectation of success**. **Finally**, the prior art reference (or references when combined) **must teach or suggest all the claim limitations**. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." *In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)*.

2. Claims 1-4, 7, 9, 21-22, 24-28, and 30-32 stand rejected under 35 USC 103(a) as being unpatentable over Dible et al. in view of Liu et al., above, and further in view of Strang (US 6,642,661).

Applicants reiterate the comments made above with respect to Dible et al. and Liu et al.

The further fact that Strang discloses a dual frequency

generation system where both an RF power and a portion of an RF bias power (at different frequencies) is supplied to a **segmented upper electrode overlying an unsegmented (single) wafer electrode** which is also supplied with another portion of the RF bias power, and **where no capacitor network is present** as in Liu et al., and where Liu et al. teaches a dual frequency system where a high frequency and a low frequency signal are combined and then supplied to both upper and lower electrodes (see col 1, lines 16-26) (i.e., operates by a different principle of operation) does not further help Examiner in producing Applicants invention.

For example, the apparatus of Strang works by a different principle of operation than the apparatus of Dible (i.e., only a **DC bias power** is disclosed in Dible, and where the **RF power (not a bias power**) is supplied to a segmented electrode supporting the wafer (chuck) and **where no matching network** is disclosed in Dible). Thus modifying Dible with the dual frequency network of Strang must also include the operation of the dual frequency power supply network of Strang **where both an RF bias power and an RF power is supplied to an overlying segmented electrode** and a **bias** RF power to a **single electrode supporting a wafer**. Such modification would change the principle of operation of Dible making the apparatus of Dible unsuitable for its intended operation, **and still not produce Applicants invention.**

Thus, modification of Dible with the dual frequency system of Strang **would still not produce Applicants invention.**

"**First,** there must be some **suggestion or motivation,** either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. **Second,** there must be a **reasonable expectation of success. Finally,** the prior art reference (or references when combined) **must teach or suggest all the claim limitations.** The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." *In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).*

"The mere fact that a worker in the art could rearrange the parts of the reference device to meet the terms of the claims on appeal is not by itself sufficient to support a finding of obviousness. The prior art must provide a motivation or reason for the worker in the art, without the benefit of appellant's specification, to make the necessary changes in the reference device." *Ex parte Chicago Rawhide Mfg. Co.,* 223 USPQ 351, 353 (Bd. Pat. App. & Inter. 1984).

Conclusion

The cited references, individually or in combination, fail to produce or suggest Applicants invention and are therefore insufficient to make out a *prima facie* case of obviousness with respect to Applicants disclosed and claimed invention.

The claims have been amended and new claims added to further clarify Applicants' disclosed and claimed invention and to overcome Examiners rejections. A favorable reconsideration of Applicants' claims is respectfully requested.

Based on the foregoing, Applicants respectfully submit that the Claims are now in condition for allowance. Such favorable action by the Examiner at an early date is respectfully solicited.

In the event that the present invention as claimed is not in condition for allowance for any reason, the Examiner is respectfully invited to call the Applicants' representative at his Bloomfield Hills, Michigan office at (248) 540-4040 such that necessary action may be taken to place the application in a condition for allowance.

U.S.S.N. 10,636,154

Respectfully submitted,

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